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INVENTORY SYSTEM PLANNING OF MARGARINE AND SHORTENING INGREDIENT WITH MONTE CARLO SIMULATION IN ADDITION TO ECONOMIC ORDER QUANTITY (EOQ) METHOD ON PT. SMART TBK

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ABSTRACT

PT. Smart Tbk. is one of multinational integrated palm oil companies which produce palm oil derivative product such as margarine and shortening. The company has problems with the high inventory cost due to un-optimal ingredient inventory system management by PPIC Department. Therefore, need further analysis about inventory planning using Monte Carlo Simulation. The objective of this research is to determine the optimum amount of each ingredient ordering in order to minimize inventory cost using Monte Carlo simulation method and EOQ. Monte Carlo simulation method is used to forecast demand while EOQ method is used to determine the inventory planning by probabilistic inventory model. By using those methods, the company can improve efficiency by Rp 951,542,844 during the year compared to current inventory policy.

Key words: *Inventory, Monte Carlo Simulation, EOQ, Probabilistic*

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Introduction

Palm oil is one of the most consumed and produced oils in the world. Palm oil is used for a variety of foods, cosmetics, hygiene products, and can also be used as a source of biofuel or biodiesel. So many uses of palm oil, many companies are plunged into this business. PT. Smart Tbk. is one of multinational company engaged in palm oil processing. Margarine and shortening are palm oil products produced by this company. The current state of industry is uncertainty because of market demand that can change at any time. Common problem encountered is inventory control, where improper lead time and forecasting errors will have an impact on the continuity of the materials supply for the production process.

One of all departments in PT Smart Tbk is the PPIC (Production Planning and Inventory Control) department. The role of PPIC is to bridge the production control planning (the availability of machine capacity, labor, raw materials, semi-finished goods, finished products) with the demand. In general, the PPIC department in this company has 3 main activities, namely Planning, Progressing and Controlling. Planning is the planning of production activities including the preparation of materials needed in a certain time interval. While Progressing is monitoring the extent to which the production plan is realized in the field. This activity is done because the difference between productions planning with actual on the field can happen at any time. Therefore, the difference should be anticipated as far as possible so that the running process does not far away from the designated plan. The Controlling stage is an evaluation of the running process and determines the next planning.

In the Controlling stage, something that we need to take attention is the plan of material needs (called lead time). Lead time is the time required from the first time the material ordered until the material is ready for use. In addition, it needs an accurate calculation in the amount of raw materials needed, as well as the amount of raw materials that are still contained in the warehouse inventory.

There are more than five hundred variants of margarine and shortening products produced by the company, both domestically and locally exported. Export products can only be produced in accordance with the number of requests, while local products can be produced according to demand based on forecasting by the Sales & Marketing department. This indicates that, local products have higher demand uncertainty compared to export products. In all local products, there are five products with highest monthly average demand, i.e. the Margarine Cream Tower, Mitra Baker's Plain Fat, Mitra Margarine Cream, Palmboom

Margarine Industry, and Baker's Plain Fat Tower. Overall, all five products accounted for more than 50% of total margarine and shortening production. There are four main types of ingredients that are most widely used in margarine and shortening production, namely BHA, MGS 90, MGU 105, and TBHQ.

Uncertainty of production planning, which has an impact on the provision of raw material quantity required, causing increase of supply cost. An approach to improve the performance of raw material inventory management, among others, can be done by using simulation and Economic Order Quantity (EOQ) method. Simulation is the imitation a real system using stochastic principle which the parameter value cannot be determined before the event occurs. This situation is same as the inventory model, where the demand value cannot be predicted with precision before the event occurs. According to Sugiharto (2007), simulation techniques proved quite effective for use in inventory management. In this study, Monte Carlo simulation is used because this technique is simple enough to describe or solve problems, including the use of programing in the computer. This study using EOQ method because this method can be used in future uncertainty demand conditions (known from the data in the past), where the demand for raw materials and waiting time is a random variable, so risk factors and uncertainty are calculated in the models.

Some research that discusses the inventory using Economic Order Quantity (EOQ) and Monte Carlo Method has been done, such as Haryadi Sarjono (2012) with the title "Planning Inventory With Monte Carlo Method Approach" and Hartono Santoso (2013) with the title "Planning Inventory Management System Ingredient From Margarine and Shortening Using Forecasting Method and EOQ at PT. Smart Tbk ". Therefore, by using Monte Carlo simulation and EOQ, it is expected to measure how much ingredient needs to be prepared so it can ensure the smoothness of the production process and obtain a minimum inventory cost.

Literature Review

1. Inventory

According to Prawirosentono (2001), inventories are current assets a company in the form of raw material inventories, semi-finished goods and in-process goods. Inventories can be categorized by function (Ristono, 2009) i.e. Inventories in Lot Size (inventory arises due to economic requirements for re-supply), Inventory reserves arise due to uncertainty, and forecasting consumer demand which is usually accompanied by forecasting errors, Inventory anticipation aims to anticipate the occurrence Supply and Supply Demand, or Price Increase, and Pipeline Inventory (inventory system can be likened to a set of stock points with the flow between those stocks).

Excessive and too little inventories do not benefit the company. Company losses if too much inventory (Tersine, 1994) because of high storage costs, high inventory purchasing costs, high risk of inventory damage, and if there is a decrease in raw material prices. While company losses if the inventory is too little (Ristono, 2009) due to running out of raw materials before the time to buy so that the production process is hampered, more often buy the matrial so the cost of messages and delivery will be higher.

2. Model of Inventory

There are two types of inventory models based on Tersine (1994) that is a deterministic inventory model whose parameters are definite or definable variables and probabilistic inventory models used when future demand is not known for certain but it is known from past data. In the deterministic inventory model, there are two models:

a. Fixed Order Size (FOS) system

assuming that the level of demand is known with certainty and fixed, so the amount of material that must be ordered and when the ordering process is fixed also. FOS system is often referred to as a quantity system, because the amount of material that must be ordered is always fixed. The number of orders that can minimize inventory costs is Economic Order Quantity (EOQ), the model can be written as follows:

$$TC\ (Q) = PR + \frac{CR}{Q} + \frac{HQ}{2} \tag{1}$$

Where R is the annual requirement (in units), P is the cost of purchasing each type, C is the ordering cost every time booking, H is the storage cost per unit per year and Q is the number of orders in the unit. Q when EOQ is calculated by $Q = \sqrt{\frac{2CR}{H}}$. The EOQ method is based on three assumptions, namely the constant and known level of demand, the waiting time is known and constant, the cost structure and the purchase price are fixed.

b. Fixed Order Interval (FOI) system

Often referre to the periodic inventory system which performed on the basis of periodic inventory level checks, not continuously as in FOS.

A probabilistic inventory model is used when future demand is not known for certain but is known from past data. In the probabilistic inventory model, raw material demand and waiting times are random variables, so that risk factors and uncertainties are taken into account in the models. The cost formula with probabilistic model is as follows:

a. The optimal number of orders $Q = \sqrt{\frac{2R[C+AE(M>B)]}{H}}$ (2)

b. Probability of a stock out $P\ (M > B) = P(s) = \frac{HQ}{AR}$ (3)

c. Reorder point $B = M + S$ (4)

d. Expectations of supply shortage $E(M > B) = \sigma.f\left[\frac{B-\bar{M}}{\sigma}\right] + (M - B)\left(1 - F\left[\frac{B-\bar{M}}{\sigma}\right]\right)$ (5)

e. The number of buffer stocks $S = \int_0^{\infty}(B - M)f(M)dM = B - \bar{M}$ (6)

f. Purchase cost of raw material $P_{tot} = R.P$ (7)

g. Cost of raw material storage $H = H\left[\frac{Q}{2} + (B - \bar{M})\right]$ (8)

h. The cost of ordering raw materials $C = \frac{R.C}{Q}$ (9)

i. Cost of material shortage $SC = \frac{AR}{Q}E(M > B)$ (10)

j. Total cost amount $TC = P + H + C + SC$ (11)

3. Monte Carlo Simulation

According to Kakiay (2004), Monte Carlo simulation is also known as Sampling Simulation or Monte Carlo Sampling Technique. This sampling simulation illustrates the possible use of sample data in the Monte Carlo method and also has been known or predicted to be distributed. This simulation uses an existing data (historical data) that is actually used in the simulation for other purposes. According to Heizer & Render (2005), when a system has elements that indicate an opportunity in its variable nature, the method of Monte Carlo simulation can be applied. The basic idea of the Monte Carlo simulation is to generate or produce a value to form a model of its variables and be studied. Here are the steps to perform Monte Carlo simulations written by Saiful et al (2013):

a. Create a probability distribution for the important variables.
b. Develop a cumulative probability distribution for each variable.
c. Create a random number interval for each variable.
d. Generating random numbers.

e. Perform regular simulations for each experiment.

Methodology

The margarine and shortening inventory system focus on five types of products with the highest average monthly demand at PT. SMART Tbk., namely: Tower of Margarine Cream, Mitra Baker's Fat Polos, Partners Margarine Krim, Palmboom Margarine Industries, and Baker's Fat Polos Tower. Four main ingredients for each type of margarine and shortening products, i.e. BHA, MGS 90, MGU 105, and TBHQ. Data of ingredient requirement is data taken from actual usage history during period of January 2013 until December 2015. There are three assumptions that exist in this research, i.e. Standard costing is based on SAP data by the end of 2015, No defect ingredients are sent by supplier, and the ingredient stock in the warehouse is not reduced because it is damaged at the time of storage (stock of ingredients is always certain to run out before 6 months of expiration). The following is the analysis steps in the research.

1. Monte Carlo simulation is to get ingredient demand for a year to be used as input for EOQ calculation. The Stages in Monte Carlo simulation are data distribution test, simulation of the number of requests, evaluation and validation of the simulation results.
2. Inventory system planning: analysis of waiting times, number of requests during waiting times, inventory system parameter calculations, and inventory cost calculations
3. omparison of inventory policies undertaken by the Department of PPIC with the results of planning the system using EOQ

Analysis and Discussion

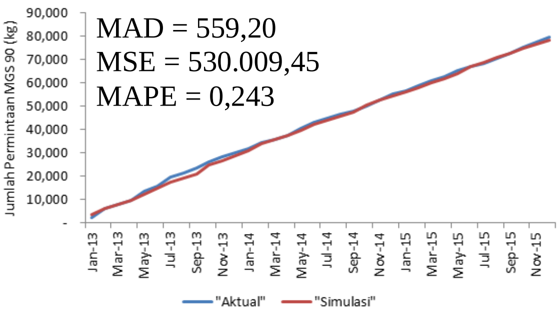
The Monte Carlo simulation is performed to obtain an ingredient request for a year that will be used as input for EOQ calculations. Stages performed include data distribution test, simulation of the number of requests, and evaluation and validation of the simulation results. The results of the Anderson-Darling distribution test on four main ingredients showed that four ingredients, i.e. MGS 90 (P-value = 0.005), MGU 105 (p-value <0.005), BHA (P-value <0.005), and TBHQ (P- value <0.005), is not normally distributed. So that will be compiled empirical distribution of demand that shows the pattern of the four ingredients by using Monte Carlo simulation.

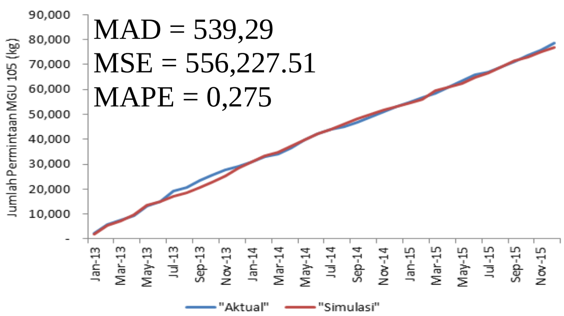
Simulation of the number of demand is done by several steps: building the empirical distribution of demand, determining random number intervals, generating random numbers, and simulating the implementation. The first stage builds the empirical distribution of demand by dividing the data into six classes, then calculating the probability of occurrence of each class. The table that describes the six classes on the four ingredients along with the probability shown in Table 1. Based on the probability of each class, a cumulative opportunity is calculated to determine the random number. The next stage is to generate a random number having an interbal 0 to 1, where the numbers 0 to 1 correspond to the cumulative opportunity. At the stage of execution of random numbers, the generation of random numbers is carried out over the next three years (36 months). The result of the random number, will be converted into the query data of four ingredients.

Table 1. Probability of MGS 90, MGU 105, BHA, and TBHQ Demand

Probability of MGS 90		Probability of MGU 105		Probability of BHA		Probability of TBHQ	
Interval of class	P(x)	Interval of class	P(x)	Interval of class	P(x)	Interval of class	P(x)
1.213,83 – 1.669,05	0,17	1.209,43 - 1.692,34	0,17	102,04 - 138,96	0,17	26,44 - 35,90	0,19
1.670,05 – 2.125,27	0,39	1.693,34 - 2.176,25	0,36	139,96 - 176,88	0,36	36,90 - 46,36	0,33
2.126,27 – 2.581,49	0,28	2.177,25 - 2.660,16	0,36	177,88 - 214,79	0,36	47,36 - 56,83	0,36
2.582,49 – 3.037,72	0,08	2.661,16 - 3.144,07	0,00	215,79 - 252,71	0,03	57,83 - 67,29	0,03
3.038,72 – 3.493,94	0,00	3.145,07 - 3.627,98	0,06	253,71 - 290,62	0,00	68,29 - 77,75	0,00
3.494,94 – 3.950,16	0,08	3.628,98 - 4.111,90	0,06	291,62 - 328,54	0,08	78,75 - 88,21	0,08

Evaluation and validation of simulation results can be seen from the MAD, MSE, and MAPE value, also graph comparison between the actual data with the simulation. Figure 1 is the fourth evaluation and validation of the simulation results.





MAD = 40.45
MSE = 3,188.72
MAPE = 0,234

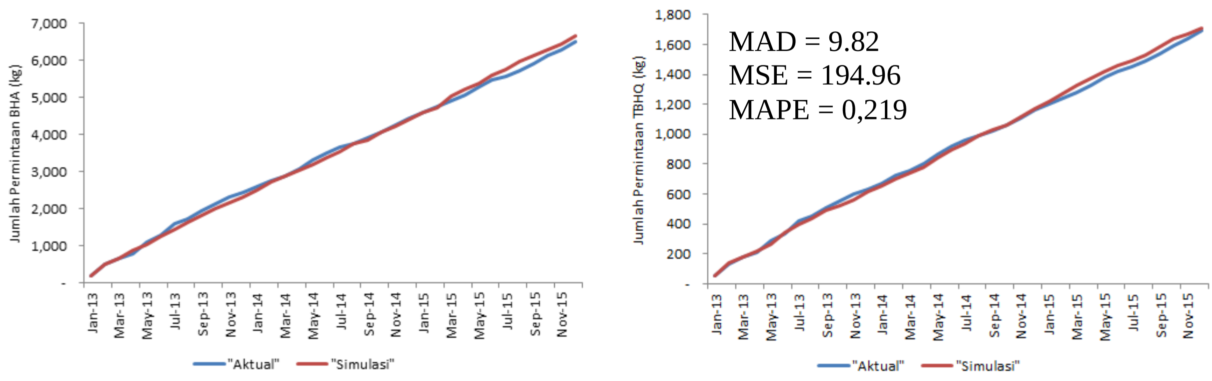


Figure 1. Plot T, Evaluation and Validation of Four Ingredient Simulation Results

Based on Figure 1, it can be seen that the simulation results follow the actual data of the ingredient request. In addition, the MAPE value can be seen that more than 75% of the simulated data reflect the actual data. So the simulation results of the fourth ingredient request with Monte Carlo method can be used to determine the inventory system in PT Smart Tbk.

In the probabilistic supply model, demand for raw materials during waiting times (daily ingredient requirements) and waiting times are random variables, so the steps that need to be done are to ensure that the ingredient waiting data, and the number of ingredient requests are normally distributed. Table 2 is a table of inormal distribution test results using Kolmogorov-Smirnov for all four ingredients. Based on Table 2, it can be seen that waiting times and ingredient requirements during waiting times are normally distributed.

The average demand for the ingredient during the waiting period is obtained from the average waiting time times the average ingredient demand. Whereas the standard deviation of ingredient demand is obtained from the root result of the average of the standard deviation time averages and the standard time demand times. The calculation results for each ingredient can be shown in the following Table 3.

Table 2. Test of Normal Distribution on Four Ingredient

Ingredient	Variable	Kolmogorov-Smirnov's Value	p-value	Conclusion
MGS 90	Needs per day	0.129	0.144	Berdistribusi normal
	Waiting time	0.094	> 0.150	Berdistribusi normal
MGU 105	Needs per day	0.145	> 0.150	Berdistribusi normal
	Waiting time	0.173	0.073	Berdistribusi normal

BHA	Needs per day	0.136	0.149	Berdistribusi normal
	Waiting time	0.156	0.054	Berdistribusi normal
TBHQ	Needs per day	0.099	> 0.150	Berdistribusi normal
	Waiting time	0.088	> 0.150	Berdistribusi normal

Table 3. Wait Time and Number of Requests During Waiting Time

	MGS 90	MGU 105	BHA	TBHQ
Average waiting time (days)	61,37	89,57	29,26	29,97
Average ingredient demand (kg / day)	73,99	52,67	6,31	1,85
Standard deviation of waiting time	3,12	10,09	4,75	7,87
Standard deviation of ingredient requests	25,40	16,65	2,10	0,67
Average ingredient requests during waiting time	4541,16	4717,68	184,61	55,47
Standard deviation of ingredient requests during waiting time	304,57	554,31	32,07	15,02

After the average and standard deviation of the ingredient request during the wait time is obtained, the inventory system paramter will be calculated which includes the optimal order quantity (Q), the reorder point (B), and the security supply (SS). Using equations 2 through 11 obtained the system inventory parameters along with the costs can be labeled as follows.

Table 4. Parameter of Research Inventory System

Parameter	MGS 90	MGU 105	BHA	TBHQ
Number of Optimal Booking (Q)	1.151,26 kg	931,87 kg	106,37 kg	64,53 kg
Expectation shortage of Supply E (M> B)	0,001463235	0,00530698	0,00010343	0,000032402
Point of Reorder (B)	5.786,44 kg	6.898,09 kg	318,53 kg	119,52 kg
Security Supplies (SS)	1.245,29 kg	2.180,42 kg	133,92 kg	64,05 kg
Purchase Cost (PC)	Rp 545.698.964,44	Rp 998.779.346,85	Rp 423.667.412,15	Rp 78.109.437,99
Storage Cost (HC)	Rp 6.923.849,10	Rp 18.521.806,65	Rp 6.839.157,20	Rp 2.447.540,76
Reservation Cost (OC)	Rp 1.932.213,25	Rp 2.373.612,48	Rp 1.688.947,98	Rp 738.276,15
The cost of material shortage (SC)	Rp 256.554,98	Rp 887.467,41	Rp 255.115,71	Rp 81.671,97
Total Inventory Cost (TC)	Rp 554.811.581,77	Rp 1.020.562.233,40	Rp 432.450.633,04	Rp 81.376.926,88

The inventory system parameters obtained by the researcher will be compared with the inventory system parameters run by the current PPIC Department. The following table shows the difference in total inventory cost over a year.

Table 5. Comparison of Total Cost Between Inventory Policy with Results

Ingredient's Name	Total Cost Inventory Current Policy	Total Cost of Inventory Research	Difference
MGS 90	Rp 824.450.547,22	Rp 554.811.581,77	Rp 269.638.965,45
MGU 105	Rp 1.277.993.651,04	Rp 1.020.562.233,40	Rp 257.431.417,64
BHA	Rp 651.578.612,51	Rp 432.450.633,04	Rp 219.127.979,47
TBHQ	Rp 286.721.409,06	Rp 81.376.926,88	Rp 205.344.482,18
Total	**Rp 3.040.744.219,83**	**Rp 2.089.201.375,09**	**Rp 951.542.844,74**

The table above shows that by planning the inventory system with Monte Carlo and EOQ method, the company can perform the efficiency of Rp 951,542,844 for a year. For that reason, it is deemed necessary to evaluate the current inventory policy.

Conclusion

The results of the ingredient demand simulation with Monte Carlo method follow actual demand, so it can be used to determine the ingredient inventory system. The result of calculation by EOQ method obtained optimal order quantity 1,151kg, 931,87 kg, 106,37 kg, and 64,53 kg for each ingredient, respectively MGS 90, MGU 105, BHA, and TBHQ. Using EOQ method, the ordering frequency is 25 times, 31 times, 22 times, and 10 times for each ingredient of MGS 90, MGU 105, BHA, and TBHQ. Total inventory cost for all four ingredients using EOQ method is Rp 2,089,201,375. By performing inventory system planning with Monte Carlo and EOQ method, the company can perform efficiency of Rp 951,542,844 or 31.29% for a year.

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